Journal of Dental Sciences (2021) 16, 311–317

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jds.com

Original Article

Effect of pediatric multivitamin syrups and effervescent tablets on the surface microhardness and roughness of restorative materials: An in vitro study

Elif Beril Gurdogan Guler [a], Gokcen Deniz Bayrak [b*], Melis Unsal [b], Senem Selvi Kuvvetli [b]

[a] Pediatric Dentist, Bonita Springs, FL, USA
[b] Department of Pediatric Dentistry, Faculty of Dentistry, University of Yeditepe, Istanbul, Turkey

Received 30 January 2020; Final revision received 11 March 2020
Available online 21 April 2020

KEYWORDS
Restorative materials;
Multivitamin syrup;
Effervescent tablet;
Surface roughness

Abstract *Background/purpose:* Multivitamin syrups and effervescent tablets are commonly used for dietary support in children; however, these preparations may have detrimental effects on the surface of restorative materials. The aim of this study was to evaluate the effect of two multivitamin syrups and two effervescent tablets taken daily on the surface microhardness and roughness of two different restorative materials.
Materials and methods: The study groups were comprised of a conventional glass ionomer cement, Ketac Molar, and a giomer, Beautifil II. A total of 140 disc-shaped specimens were prepared and randomly assigned to 5 subgroups. The samples were immersed in 4 multivitamins (Supradyne syrup, Supradyne effervescent, Sambucol syrup, Sambucol effervescent) and deionized water (control group) for 2 min once a day for 28 days. Surface microhardness and roughness measurements were recorded at baseline and on the 7th, 14th, 21st and 28th days. Surface microhardness was measured using a Vickers hardness tester and surface roughness was determined using a profilometer.
Results: For all subgroups; the surface microhardness values of the Ketac Molar and Beautifil II demonstrated a statistically significant decrease from the baseline to the 28th day measurements ($p < 0.05$), while the surface roughness displayed increased values that were found to be statistically significant ($p < 0.05$). The Ketac Molar surface roughness values were significantly higher than Beautifil II in all subgroups for all measurement days ($p = 0.0001$).
Conclusion: The prolonged use of multivitamin syrups and effervescent tablets may have negative effects on the physical properties of restorative materials.

* Corresponding author. Yeditepe University Faculty of Dentistry, Department of Pediatric Dentistry, Goztepe, 34728, Istanbul, Turkey.
E-mail address: gdenizbayrak@gmail.com (G.D. Bayrak).

https://doi.org/10.1016/j.jds.2020.03.017

Introduction

Children require the adequate amount of vitamins and minerals to maintain healthy tissue and organ function as well as for growth and development. Since our body cannot produce the required amount of all the essential vitamins on its own, these nutrients must be obtained from external sources such as a balanced diet, or when necessary, supplements. Vitamin supplements can be found in the form of liquid (syrup), pills, chewable tablets, gummies, lozenges or effervescent tablets and contain a varying combination of vitamins, minerals and other ingredients.[1] Syrups and effervescent tablets are commonly used as an alternative to make taking vitamins a more intriguing and palatable experience for children compared to the other forms of vitamins.[2] These types of vitamins are easy to take and are typically recommended by pediatricians for dietary support in children. However, the solubility of some substances in both syrups and effervescent tablets are pH dependent, therefore these are acidic preparations formulated to maintain chemical stability, optimize the efficacy of the substances and ensure optimal drug dispersion. The acidity also aids in improving the flavor of the solution.[3] The effervescent form of vitamins consist of a soluble organic acid (usually citric, tartaric, malic, fumaric or adipic acid), an alkali metal carbonate salt (sodium bicarbonate/carbonate or potassium bicarbonate/carbonate) and differing concentrations of vitamins and/or minerals.[4,5] Upon contact with water, the compounds present in the tablet form carbon dioxide and produce a fizzy effect which results in a carbonated, or sparkling, liquid drink.[5]

It has been reported that liquid vitamin/multivitamin preparations have an erosive potential.[6] Results of previous studies investigating the effect of effervescent vitamin/multivitamins on dental hard tissue, although few in number, suggest that effervescent preparations are also associated with dental erosion.[5,7–9] Various studies also showed that chewable vitamin tablets, ascorbic acid (vitamin c) preparations, multivitamin syrups and effervescent tablets reduce the surface microhardness of teeth and increase the risk of dental erosion due to their acid content and low pH.[5,7–11] Previous studies have focused mostly on the effect of pediatric liquid medications (antitussive, analgesic, antibiotic and antihistaminic) on primary as well as permanent enamel.[2,6,12–15] The results of these studies have shown that the use of the syrup form of supplements can act as extrinsic agents for dental erosion and have negative effects on dental hard tissue, due to the high titratable acidity (total acidity) and low pH of the solution; which can result in the degradation of resin-based materials depending on the consumption frequency.[15–17] The risk of dental erosion increases when the syrup is given frequently ($3 \leq$ times a day) or before going to sleep.[15] The consumption of these medications at some point in life seems inevitable, therefore it is essential that the erosive potential of these frequently recommended solutions is identified.

There are few recent studies which have investigated the effect of multivitamin syrups on dental materials.[18] To the best of our knowledge, there are currently no studies which focus on investigating the microhardness and surface roughness of dental materials subjected to multivitamin effervescent tablets. Additionally, there are no studies regarding their effect on glass ionomer restorations in terms of the same parameters. The only study which involves the effect of pediatric syrup multivitamins on glass ionomer cements evaluated color stability.[19] Therefore, the aim of this study was to evaluate and compare the effect of two different pediatric multivitamin syrups and effervescent tablets taken daily for 28 days on the surface microhardness and roughness of two different restorative materials.

Materials and methods

The study groups were comprised of two different restorative materials; Ketac Molar (3M ESPE, Seefeld, Germany), and Beautifil II (Shofu Inc., Kyoto, Japan). The multivitamins tested were Supradyn Stars syrup (Bayer, Leverkusen, Germany), Supradyn effervescent (Bayer), Sambucol syrup (Razei Bar, Jerusalem, Israel) and Sambucol effervescent (Razei Bar). The endogenous pH of all the medications were measured using a digital pH electrode meter (OAKTON, Vernon Hills, IL, USA). The erosion related ingredients, pH values and the manufacturers of the multivitamin syrups are given in Table 1.

Preparation of specimens

A total of 140 disc-shaped specimens (8 mm × 2 mm), 70 samples from each restorative material, were prepared as

Table 1 pH values of medications included in the study.

Tested medication	Brand name/ Manufacturer	Erosion related ingredient	pH
Supradyn® Stars syrup	Bayer	Ascorbic acid, Citric acid monohydrate	4.10
Supradyn® effervescent tablet	Bayer	Ascorbic acid, Citric acid	4.46
Sambucol® syrup	Razei Bar	Ascorbic acid, Citric acid	4.02
Sambucol® effervescent tablet	Razei Bar	Ascorbic acid, Citric acid monohydrate	4.71

described on each of the material's manuals for the surface microhardness and roughness tests. Each material was inserted into a standard plastic mold and pressed between two opposing Mylar strips. The conventional glass ionomer cement was then allowed to set at room temperature for 10 min. The giomer material was polymerized through the glass slide using a halogen curing unit (Optilux 501, Kerr, Pomona, CA, USA) with a light intensity of 500 mW/cm2, according to the manufacturer's instructions. After removing the specimens from the mold, the samples were subjected to a polishing system (Sof-Lex, 3M-ESPE, St. Paul, MN, USA) and stored in deionized water at 37 °C for 24 h. Initial surface microhardness and roughness values were measured and recorded.

Immersion cycles

The specimens of each restorative materials were randomly divided into five subgroups according to the immersion medium (Supradyn Stars syrup, Supradyn effervescent, Sambucol syrup, Sambucol effervescent and deionized water). The immersion cycling protocol used in this study was adopted in order to simulate actual consumption of the multivitamins. Over a period of 28 days, the specimens were immersed in either 200 ml water with 1 effervescent tablet or in 10 ml of the multivitamin syrup for 2 min a day with 24 h intervals between the immersion cycles. After each immersion cycle, the specimens were both washed and stored in deionized water until the next cycle. The syrups/effervescents were refreshed before each immersion. The control specimens were kept in deionized water during the entire experiment (28 days), with the solution refreshed daily. Surface microhardness ($n = 7$) and surface roughness ($n = 7$) were evaluated on the 7th, 14th and 28th days for each disc-shaped specimen.

Microhardness tests

The surface microhardness values were determined using a Buehler Micromet 5114 (Buehler, Lake Bluff, IL, USA) and the obtained values were recorded as Vickers Hardness Number (VHN). Three indentations were made in total at different points on each specimen no closer than 1 mm to the adjacent indentation with a 100 gr load for 15 s. The average of the three values obtained were recorded as VHN.

Surface roughness tests

The mean surface roughness (Ra) values for all specimens were measured with a profilometer (Perthometer M1, Mahr GmbH, Göttingen, Germany). Three successive measurements in different directions were recorded for each surface, and average surface roughness values were obtained. The cut-off value for surface roughness was 0.25 mm, and the sampling length for each measurement was 1.5 mm. The profilometer was calibrated before each new measurement session.

Statistical analysis

The statistical analysis was performed using NCSS 2007 Statistical Software program (Number Cruncher Statistical System, Kaysville, Utah, USA). Statistical methods used for data analysis were one-way analysis of variance (for intergroup comparisons), Tukey multiple comparison test (for subgroup comparisons), paired-sample t-test (for day to day comparisons), Newman Keuls multiple comparison test (for subgroup comparisons) and independent t-test (for the comparison of two groups). Results were evaluated at a level of $p < 0.05$ significance.

Results

Mean VHN values and standard deviations determined in the subgroups of the Ketac Molar group for the baseline and each measurement day are summarized in Fig. 1. In all the subgroups, the mean microhardness values showed a statistically significant decrease from the baseline to the 28th day measurements ($p < 0.05$). The lowest microhardness values were determined on the 28th day in the

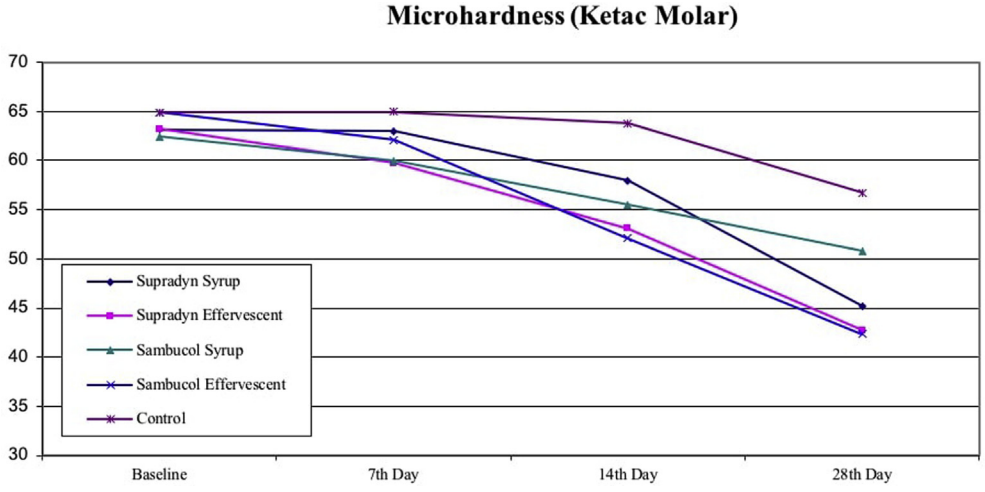

Figure 1 Mean VHN measured in subgroups of the Ketac Molar material.

Sambucol effervescent subgroup. On the 28th day, the Supradyn and Sambucol effervescents showed significantly lower values compared to the Sambucol syrup subgroup ($p = 0.0001$).

The mean and standard deviations in the VHN values for the subgroups of Beautifil II at the baseline, 7th, 14th and 28th days, are summarized in Fig. 2. In all the vitamin and control subgroups, the mean microhardness values showed a statistically significant decrease from the baseline to the 28th day measurements ($p < 0.05$). The Supradyn effervescent group displayed the lowest microhardness values on the 28th day. On the 28th day, the mean microhardness values of the control group were significantly higher than the Supradyn syrup and Supradyn effervescent group ($p = 0.035$, $p = 0.033$). There was no statistically significant difference between the other groups on the 28th day ($p > 0.05$). For all measurement days, in the Supradyn and Sambucol effervescent subgroups, Ketac Molar demonstrated significantly lower microhardness values compared to the Beautifil II material ($p < 0.05$) (Table 2).

The mean and standard deviation Ra values for all subgroups of the Ketac Molar group, from baseline to the 28th day, are presented in Fig. 3. In all the vitamin subgroups, the mean Ra values showed a statistically significant increase from the baseline to the 28th day measurements ($p < 0.05$). The highest Ra values were determined on the 28th day in the Supradyn effervescent subgroup. On the 28th day, Supradyn effervescent showed significantly higher roughness values compared to Sambucol effervescent and syrup ($p = 0.0001$).

The distribution of mean Ra values of Beautifil II for all subgroups over a period of 28 days can be seen in Fig. 4. In all the vitamin subgroups, the mean Ra values showed a statistically significant increase from baseline to the 28th day measurements ($p < 0.05$). The highest Ra values were determined on the 28th day in the Supradyn effervescent subgroup. On the 14th and 28th days, the Supradyn effervescent subgroup showed significantly higher values compared to the other subgroups ($p < 0.05$). For all measurement days, in all the vitamin subgroups and the control group, Ketac Molar showed higher Ra values compared to the Beautifil II material ($p = 0.0001$) (Table 3).

Discussion

The pH information of the multivitamins selected for this study were not included by the manufacturers. Therefore, the pH of each solution was measured prior to the study using a digital pH meter. The recorded pH values for Supradyn syrup, Supradyn effervescent, Sambucol syrup and Sambucol effervescent were 4.10, 4.46, 4.02 and 4.71 respectively; all of which are below the critical pH value of 5.5. The acidic medications or supplements cause a softening effect on dental materials which results in higher surface roughness and low wear resistance. Previous studies have shown that acidic conditions result in the degradation of glass ionomer cements as well as composite resins.[20–23] In light of these studies, it is possible to deduce that material degradation will occur to some extent when these formulations are taken.

It has been reported that the erosive potential of a solution is not solely dependent on a low pH value. The titratable acidity, type of acid and mineral content of the preparation is also of great importance.[15] In the current study, other than pH, none of these properties were investigated. Studies have speculated that erosion is related to pH when dental hard tissue is exposed to the erosive potential for a short period of time; titratable acidity on the other hand was associated with long-term exposure.[24] Hara and Zero reported that titratable acidity was less correlated with dental erosion; however, pH was found to be a good predictor for dental erosion.[25]

In the current study, the Ketac Molar material demonstrated lower microhardness values compared to the Beautifil II, for baseline and all the measurement days in the Supradyn and Sambucol effervescent subgroups ($p < 0.05$). For all measurement days, in all the subgroups, Ketac Molar demonstrated higher surface roughness values compared to the Beautifil II material ($p = 0.0001$). This result is most likely due to the fact that giomer is a resin-modified GIC material, which makes it more resistant to acidic challenges compared to a conventional GIC. Moreover, the results of the present study demonstrate that effervescent tablets have a more negative effect on the microhardness and surface roughness of restorative

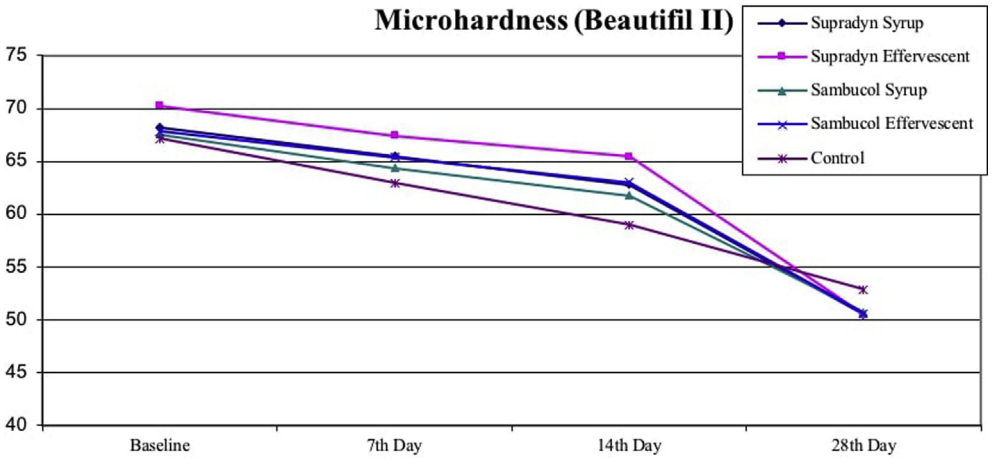

Figure 2 Mean VHN values measured in the subgroups for Beautifil II.

Table 2 Comparison of mean VHN values for material groups and tested vitamins for all measurement days.

Microhardness		Ketac Molar	Beautifil II	p*
Supradyn Syrup	Baseline	63.17 ± 6.02	68.20 ± 2.63	0.066
	7th Day	63.01 ± 3.50	65.51 ± 2.18	0.134
	14th Day	57.93 ± 4.39	62.77 ± 2.37	**0.025**
	28th Day	45.22 ± 0.83	50.47 ± 0.77	**0.0001**
Supradyn	Baseline	63.20 ± 3.66	70.25 ± 2.65	**0.001**
Effervescent	7th Day	59.73 ± 3.29	67.44 ± 0.91	**0.0001**
	14th Day	53.06 ± 1.96	65.44 ± 1.85	**0.0001**
	28th Day	42.71 ± 3.93	50.45 ± 1.66	**0.0001**
Sambucol Syrup	Baseline	62.45 ± 2.52	67.55 ± 2.46	**0.002**
	7th Day	59.96 ± 1.41	64.36 ± 1.18	**0.0001**
	14th Day	55.51 ± 1.23	61.73 ± 1.91	**0.0001**
	28th Day	50.78 ± 1.24	50.73 ± 1.18	0.942
Sambucol	Baseline	64.89 ± 2.74	67.81 ± 1.92	**0.039**
Effervescent	7th Day	62.10 ± 1.69	65.41 ± 0.96	**0.001**
	14th Day	52.06 ± 0.71	63.02 ± 1.79	**0.0001**
	28th Day	42.36 ± 0.73	50.60 ± 0.66	**0.0001**
Control	Baseline	64.88 ± 2.13	67.15 ± 2.59	0.098
	7th Day	64.97 ± 2.23	62.96 ± 1.93	0.096
	14th Day	63.78 ± 3.13	58.95 ± 3.26	**0.015**
	28th Day	56.72 ± 3.10	52.85 ± 2.33	**0.022**

p* Independent t-test.

materials compared to the syrup form. The highest surface roughness values were observed in the 28th day measurements for the Supradyn effervescent subgroup for both materials. Since multivitamins are generally used for a prolonged period of time, these results indicate that effervescent tablets may have a more aggressive effect on GICs compared to the syrup form.

In the present study, a gradual decrease in surface microhardness as well as an increase in surface roughness was observed in the control subgroups for both materials. Compared to the vitamin supplement groups these changes were significantly less, which can be attributed to the lower pH of the multivitamins. Deionized water was chosen as the control medium due to its non-acidic pH and also as the storage media due to its ability to simulate the wet oral cavity. Lima et al. reported that Ketac Molar absorbed more water when stored in deionized water compared to artificial saliva due to osmotic pressure.[26] Previous studies have also reported that resin-modified GICs demonstrate lower water uptake compared to conventional GICs.[20,27] Studies have reported that water uptake can alter and reduce the mechanical and physical properties of resin-based restorations due to hydrolysis of the silane interface and loss of chemical bonds between filler particles which ultimately causes degradation of the material.[28] Additionally, softening of the material's surface causes the displacement of filler particles from the outer surface of the resin matrix which contributes to increased surface roughness and reduced surface microhardness.[29] It is debatable whether the immersion time of 2 min is enough to cause such degradation in either material. Therefore, it can be speculated that the solubility and water uptake of the material during storage most likely caused this change in the control subgroups. The

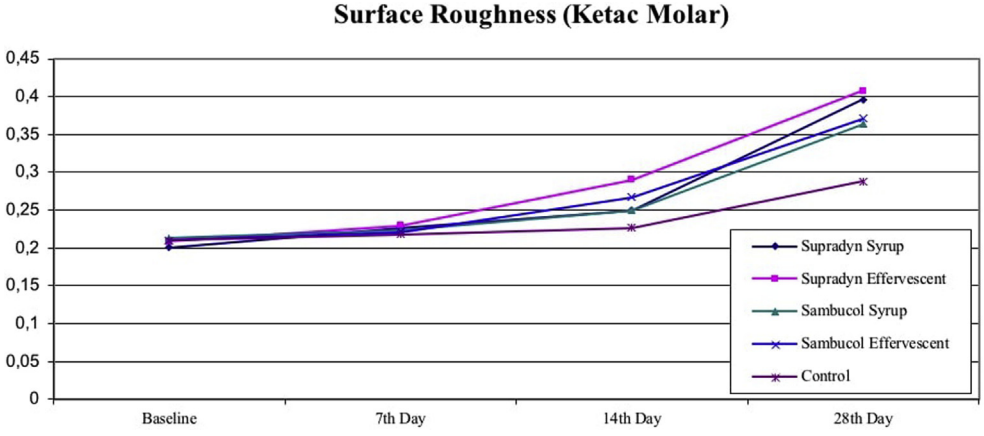

Figure 3 Mean Ra values measured for Ketac Molar subgroups (μm).

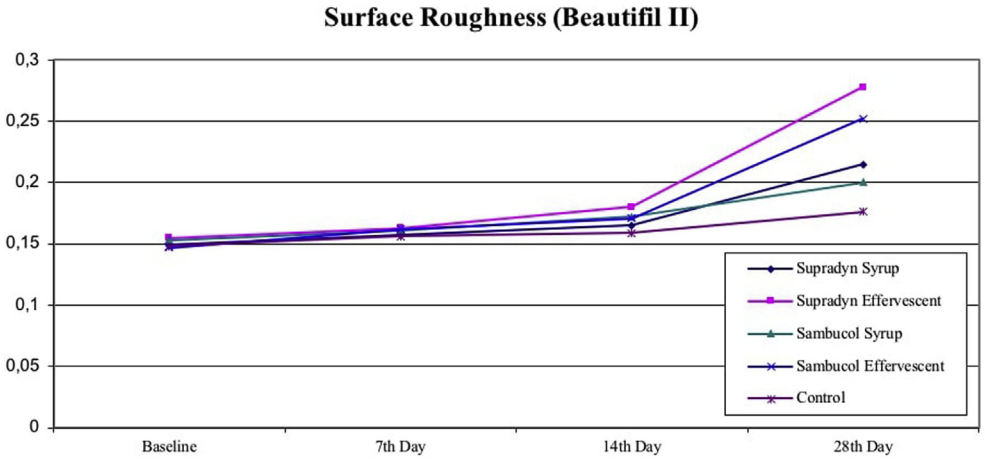

Figure 4 Mean Ra values measured in the Beautifil II subgroups (μm).

Table 3 Comparison of mean Ra values for material groups and tested vitamin supplements for all measurement days.

Surface roughness		Ketac Molar	Beautifil II	p*
Supradyn Syrup	Baseline	0.201 ± 0.009	0.149 ± 0.006	**0.0001**
	7th Day	0.227 ± 0.007	0.157 ± 0.007	**0.0001**
	14th Day	0.250 ± 0.004	0.165 ± 0.006	**0.0001**
	28th Day	0.396 ± 0.010	0.215 ± 0.005	**0.0001**
Supradyn Effervescent	Baseline	0.209 ± 0.010	0.155 ± 0.002	**0.0001**
	7th Day	0.230 ± 0.008	0.163 ± 0.004	**0.0001**
	14th Day	0.290 ± 0.050	0.180 ± 0.004	**0.0001**
	28th Day	0.408 ± 0.015	0.278 ± 0.005	**0.0001**
Sambucol Syrup	Baseline	0.213 ± 0.012	0.153 ± 0.004	**0.0001**
	7th Day	0.223 ± 0.005	0.161 ± 0.004	**0.0001**
	14th Day	0.250 ± 0.002	0.172 ± 0.005	**0.0001**
	28th Day	0.364 ± 0.010	0.200 ± 0.006	**0.0001**
Sambucol Effervescent	Baseline	0.210 ± 0.008	0.147 ± 0.003	**0.0001**
	7th Day	0.221 ± 0.004	0.162 ± 0.005	**0.0001**
	14th Day	0.267 ± 0.005	0.171 ± 0.005	**0.0001**
	28th Day	0.371 ± 0.012	0.252 ± 0.015	**0.0001**
Control	Baseline	0.210 ± 0.012	0.148 ± 0.006	**0.0001**
	7th Day	0.218 ± 0.007	0.156 ± 0.004	**0.0001**
	14th Day	0.227 ± 0.005	0.159 ± 0.003	**0.0001**
	28th Day	0.288 ± 0.019	0.176 ± 0.006	**0.0001**

p* Independent t-test.

results of a study by Münchow et al. reported similar results to the present study in that deionized water was found to have increased the resin specimen's surface roughness which the authors also attributed to water absorption and material solubility.[29]

It is important to uncover the erosive potential of commonly used vitamin supplements for children due to the possible detrimental effects of dental erosion such as caries formation, hypersensitivity, difficulties in eating, extensive hard tissue loss resulting in reduced vertical dimension, and pulpitis-related complications.[11,30] Although the effervescent form of vitamins is useful in young children, there are other important factors to take into account such as the presence of bicarbonate and high sodium and/or potassium content. The effervescent should be allowed to dissolve completely before consumption and their use is not suitable for children with renal insufficiency. Some effervescents require large volumes of water for the adequate dispersion of the product, which may be difficult for young children to consume.[11] With these points in mind, and considering their erosive potential to both enamel and restorative materials, caution should be advised when prescribing effervescent formulations to young children. In patients with high risk, syrup may be recommended instead of effervescent tablets. In general, for both syrup and effervescent forms of multivitamins, precautions should be taken such as not keeping the formulation in the mouth for too long and not brushing directly after use. For the neutralization of pH, fluoride or calcium phosphate containing products, sugar-free chewing gums or rinsing the mouth with water may be recommended.[16] On a side note, it may be beneficial for future studies to focus on the sugar content and titratable

acidity of commonly used multivitamin effervescents and their cariogenic potential.

According to the results of this study, non-resin-based materials such as Ketac Molar may be more susceptible to effervescent tablets. Therefore, it is important to choose a suitable restorative material depending on the type of the multivitamin used or vice-versa. Also, necessary preventive measures should be taken in children who use multivitamins. Parents may be advised to rinse the child's mouth with water following vitamin consumption. Parents should be encouraged by pediatricians to periodically visit the pediatric dentist for monitorization of existing restorations as well as routine check-ups. Further clinical research is required to support the findings of this study.

Declaration of Competing Interest

The authors have no conflicts of interest relevant to this article.

References

1. Mistry P, Batchelor H. Evidence of acceptability of oral paediatric medicines: a review. *J Pharm Pharmacol* 2017;69:361—76.
2. Mali GV, Dodamani AS, Karibasappa GN, Kumar PV, Jain VM. Effect of conventional and sugar free pediatric syrup formulations on primary tooth enamel hardness: an in vitro study. *J Indian Soc Pedod Prev Dent* 2015;33:331—6.
3. Maguire A, Baqir W, Nunn JH. Are sugar-free medicines more erosive than sugar-containing medicines? An in vitro study of pediatric medicines with prolonged oral clearance used regularly and long-term by children. *Int J Pediatr Dent* 2007;17:231—8.
4. Stahl H. Effervescent dosage manufacturing. *Pharmaceut Technol* 2003;15:25—8.
5. Wegehaupt FJ, Lunghi N, Hogger VMG, Attin T. Erosive potential of vitamin and vitamin+mineral effervescent tablets. *Swiss Dent J* 2016;126:457—65.
6. Tupalli AR, Satish B, Shetty BR, Battu S, Kumar JP, Nagaraju B. Evaluation of the erosive potential of various pediatric liquid medicaments: an in vitro study. *J Int Oral Health* 2014;6:59—65.
7. Meurman JH, Murotomaa H. Effect of effervescent vitamin C preparations on bovine teeth and on some clinical and salivary parameters in man. *Scand J Dent Res* 1986;94:491—9.
8. Nunn JH, Ng SK, Sharkey I, Coulthard M. The dental implications of chronic use of acidic medicines in medically compromised children. *Pharm World Sci* 2001;23:118—9.
9. Lussi A, Megert B, Shellis RP, Wang X. Analysis of the erosive effects of different dietary substances and medications. *Br J Nutr* 2012;107:252—62.
10. Lussi A, Kohler N, Zero D, Schaffner M, Megert B. A comparison of the erosive potential of different beverage in primary and permanent teeth using an in vitro model. *Eur J Oral Sci* 2000;108:110—4.
11. Pasdar N, Alaghehmand H, Mottaghi F, Tavassoli M. Experimental study of iron and multivitamin drops on enamel microhardness of primary tooth. *J Int Soc Prev Community Dent* 2015;5:518—24.
12. McNally LM, Barbour ME, O'Sullivan DJ, Jagger DC. An in vitro investigation of the effect of some analgesics on human enamel. *J Oral Rehabil* 2006;33:529—32.
13. Babu KL, Rai K, Hedge AM. Pediatric liquid medicaments-do they erode the teeth surface? An in vitro study: part I. *J Clin Pediatr Dent* 2008;32:189—94.
14. Wegehaupt F, Günthart N, Sener B, Attin T. Prevention of erosive/abrasive enamel wear due to orange juice modified with dietary supplements. *Oral Dis* 2011;17:508—14.
15. Scatena C, Galafassi D, Gomes-Silva JM, Borsatto MC, Serra MC. In vitro erosive effect of pediatric medicines on deciduous tooth enamel. *Braz Dent J* 2014;25:22—7.
16. Lussi A, Hellwig E, Ganss C, Jaeggi T. Dental erosion. *Operat Dent* 2009;34:251—62.
17. Valinoti AC, Neves BG, da Silva EM, Maia LC. Surface degredation of composite resins by acidic medicines and pH-cycling. *J Appl Oral Sci* 2008;16:257—65.
18. Afzali BM, Ghasemi A, Mirani A, Abdolazimi Z, Baghban AA, Kharazifard MJ. Effect of ingested liquids on color change of composite resins. *J Dent* 2015;12:577—84.
19. Tuzuner T, Turgut S, Baygin O, Yilmaz N, Tuna EB, Ozen B. Effects of different pediatric drugs on the color stability of various restorative materials applicable in pediatric dentistry. *BioMed Res Int* 2017;9684193:1—5.
20. Silva RC, Zuanon ACC. Surface roughness of glass ionomer cements indicated for atraumatic restorative treatment (ART). *Braz Dent J* 2006;17:106—9.
21. De Witte AM, De Maeyer EA, Verbeeck RM. Surface roughening of glass ionomer cements by neutral NaF solutions. *Biomaterials* 2003;24:1995—2000.
22. Aliping-Mckenzie M, Linden RWA, Nicholson JW. The effect of Coca-Cola and fruit juices on the surface hardness of glass ionomers and compomers. *J Oral Rehabil* 2004;31:1046—52.
23. Soares LE, Soares AL, De Oliveira R, Nahorny S. The effects of acid erosion and remineralization on enamel and three different dental materials: FT-Raman spectroscopy and scanning electron microscopy analysis. *Microsc Res Tech* 2016;79:646—56.
24. Jensdottir T, Holbrook P, Nauntofte B, Buchwald C, Bardow A. Immediate erosive potential of cola drinks and orange juices. *J Dent Res* 2006;85:226—30.
25. Hara AT, Zero DT. Analysis of the erosive potential of calcium-containing acidic beverages. *Eur J Oral Sci* 2008;116:60—5.
26. Lima RBW, Farias JFG, Andrade AKM, Silva FDSCM, Duarte RM. Water sorption and solubility of glass ionomer cements indicated for atraumatic restorative treatment considering the time and the pH of the storage solution. *Rev Gaucha Odontol* 2018;66:29—34.
27. Amaral MT, Guedes-Pinto AC, Chevitarese O. Effects of a glass ionomer cement on the remineralization of occlusal caries-an in situ study. *Braz Oral Res* 2006;20:91—6.
28. Tanthanuch S, Kukiattrakoon B, Eiam-O-Pas K, et al. Surface changes of various bulk-fill resin-based composites after exposure to different food-simulating liquid and beverages. *J Esthetic Restor Dent* 2018;30:126—35.
29. Münchow EA, Ferreira AC, Machado RM, Ramos TS, Rodrigues-Junior SA, Zanchi CH. Effect of acidic solutions on the surface degredation of a micro-hybrid composite resin. *Braz Dent J* 2014;25:321—6.
30. Linnett V, Seow WK. Dental erosion in children: a literature review. *Pediatr Dent* 2001;23:37—43.